2025

AP® Physics C: Electricity and Magnetism

Sample Student Responses and Scoring Commentary

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Free-Response Question 2

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- ☑ **Student Samples**
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Question 2: Translation Between Representations (TBR) — 12 points

A

For drawing a bar at $\frac{1}{4}T$ — **Point A1**

For drawing a bar at $\frac{1}{4}T$ that has a height of 3 units — **Point A2**

For indicating that $|\mathcal{E}|$ is zero at times $t = 0$ and $\frac{1}{2}T$ — **Point A3**

Example Response

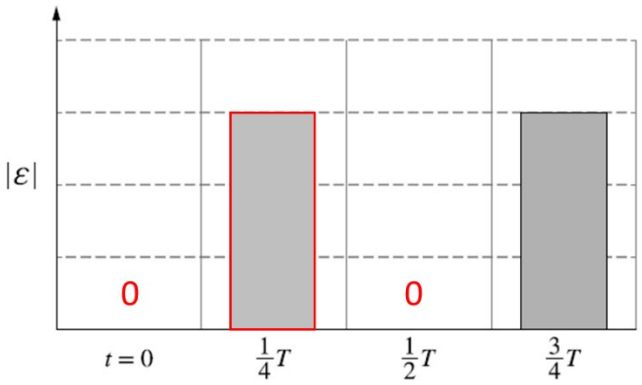

Figure 2

B

For a multistep derivation that includes the equation $\mathcal{E} = -\frac{d\Phi_B}{dt}$ — **Point B1**

Scoring Note: The negative sign does not have to be present in the expression for this point to be earned.

For a correct expression for the induced emf (e.g., $\mathcal{E} = BA\omega\sin(\omega t)$) — **Point B2**

For using Ohm's law to relate current and emf (e.g., $I = \frac{\mathcal{E}}{R}$) — **Point B3**

For a correct expression for the absolute value of the maximum induced current (e.g., $I = \frac{BA\omega}{R}$) — **Point B4**

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Example Response

$$\mathcal{E} = -\frac{d\Phi_B}{dt}$$

$$\mathcal{E} = -\frac{d}{dt}\left[BA\cos(\omega t)\right] = BA\omega\sin(\omega t)$$

$$\mathcal{E}_{max} = BA\omega$$

$$I = \frac{\Delta V}{R} = \frac{\mathcal{E}}{R}$$

$$I_{max} = \frac{\mathcal{E}_{max}}{R} = \frac{BA\omega}{R}$$

C	For a curve that is approximately sinusoidal	**Point C1**
	For a curve that shows exactly two cycles	**Point C2**
	For a curve that starts at the origin and has equal maximum values and equal minimum values **Scoring Note:** A curve that starts and ends at $P = 0$ and has a single maximum can earn this point.	**Point C3**

Example Response

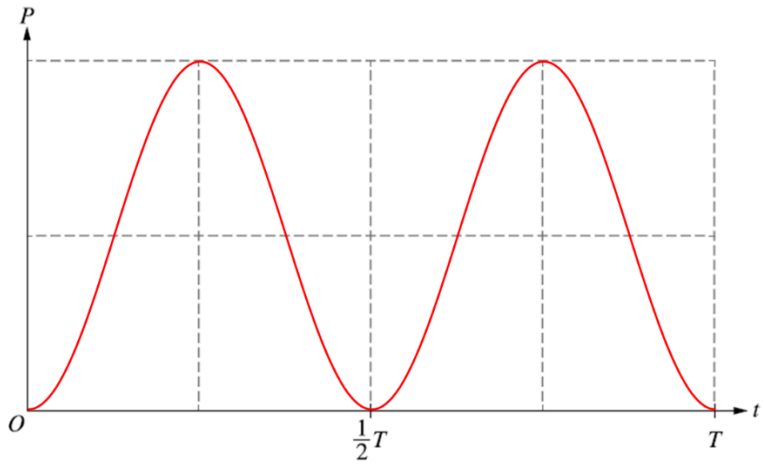

Figure 3

D	For correctly indicating whether the representations are consistent in parts A and C	**Point D1**
	For a correct justification that indicates that the maxima and/or minima of the graph in part C align with the bars drawn in part A because P is proportional to $\mathcal{E}^2$	**Point D2**

Example Response

Yes, part C is consistent with part A. P is proportional to $\mathcal{E}^2$. *When* $|\mathcal{E}|$ *is maximum, P is maximum.*

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Question 2: Version J

PART A

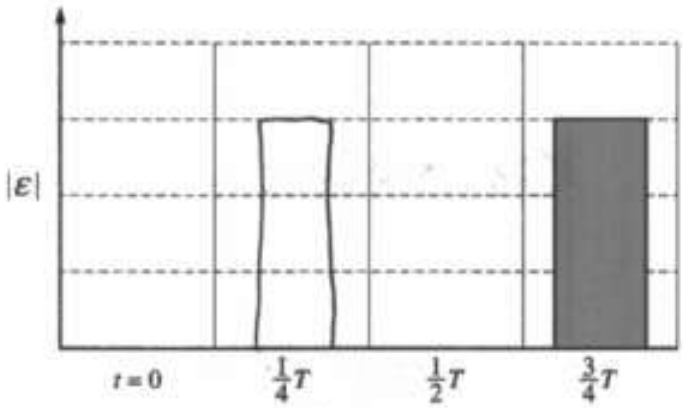

Figure 2

PART B

$|\mathcal{E}| = \left|\frac{d\Phi}{dt}\right| = BA\omega \sin(\omega t)$ goes to 1 for max

$I = \frac{\mathcal{E}}{R} = \frac{BA\omega}{R}$

$I = \frac{BA\omega}{R}$

Question 2: Version J continues on the next page.

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Question 2: Version J

PART C

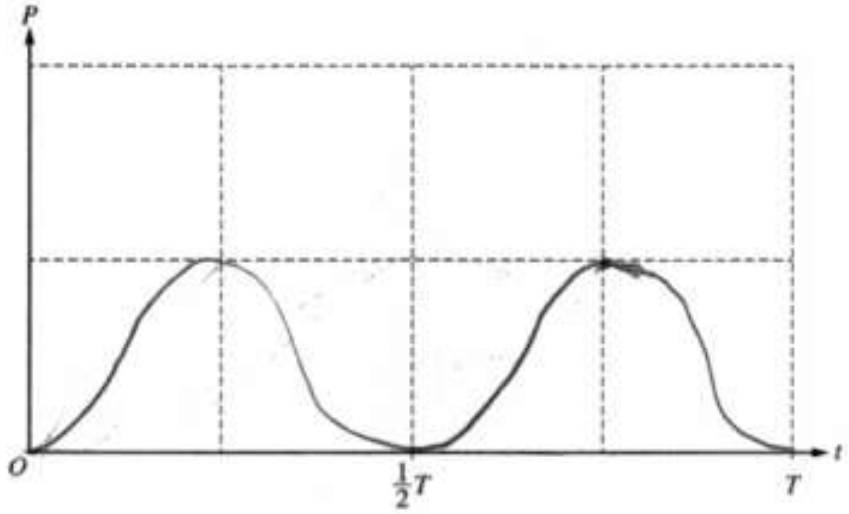

Figure 3

$P = I^2R = \left(\frac{\beta A w \sin(wt)}{R}\right)^2 R$

$P = I\mathcal{E}$

PART D

It is consistent with what I drew in part A, as the function at their max at $\frac{1}{4}T$ and $\frac{3}{4}T$ which matches the behaviors. This is because $P = I|\mathcal{E}|$, and since both functions I and $|\mathcal{E}|$ include $\sin(wt)$ and everything else is constant, the graph looks like a $\sin(wt)^2$ function.

Go to Question 3 in Bluebook when you're done with this question.

Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 2: Version J

PART A

$\mathcal{E} = -\frac{d\Phi}{dt} = BA\omega\sin$

$\mathcal{E} = \omega BA\sin(\omega t)$

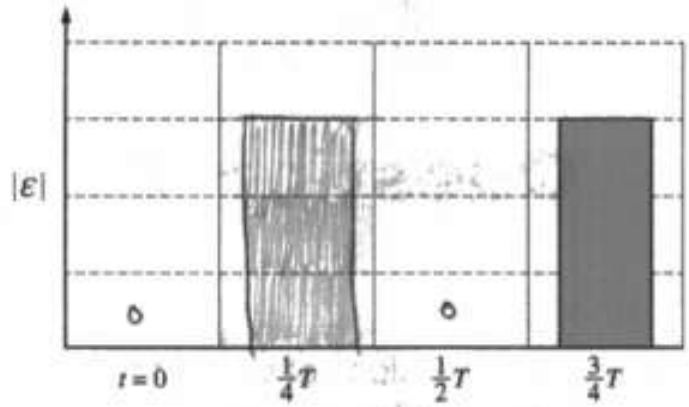

Figure 2

PART B $\mathcal{E} = -\frac{d\Phi}{dt} = \omega BA\sin(\omega t)$

$I = \frac{\mathcal{E}}{R}$

$I(t) = \frac{\omega BA\sin(\omega t)}{R}$

$I(1) = I_{max} = \frac{\omega BA\sin(\omega)}{R}$

Question 2: Version J continues on the next page.

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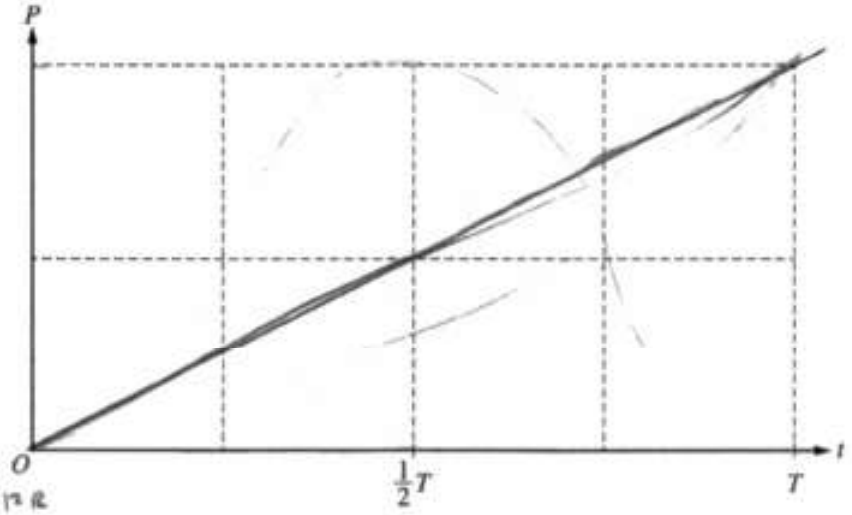
Question 2: Version J

PART C



$P = IOV = \frac{V^2}{R} = I^2R$

$\frac{(\omega)^2 B^2 A^2 R \sin^2(\omega t)}{R}$

Figure 3

PART D

Buer equals the $|\mathcal{E}|^2$ divided by resistance or times the current

$P = IOV = \frac{\omega^2 B^2 A^2 \sin^2(\omega t)}{R} = I^2R$

The P graph is consistent since all the terms are squared & sinθ is now squared & linear

Go to Question 3 in Bluebook when you're done with this question.

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Question 2: Version J

PART A

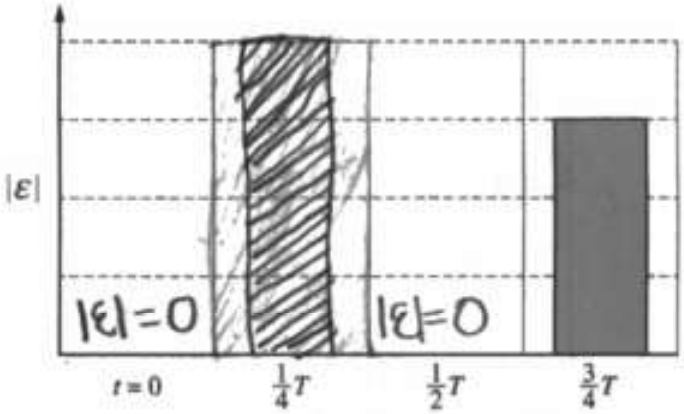

Figure 2

PART B

$|\mathcal{E}| = N\left|\frac{d\Phi_B}{dt}\right|$

Question 2: Version J continues on the next page.

Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 2: Version J

PART C

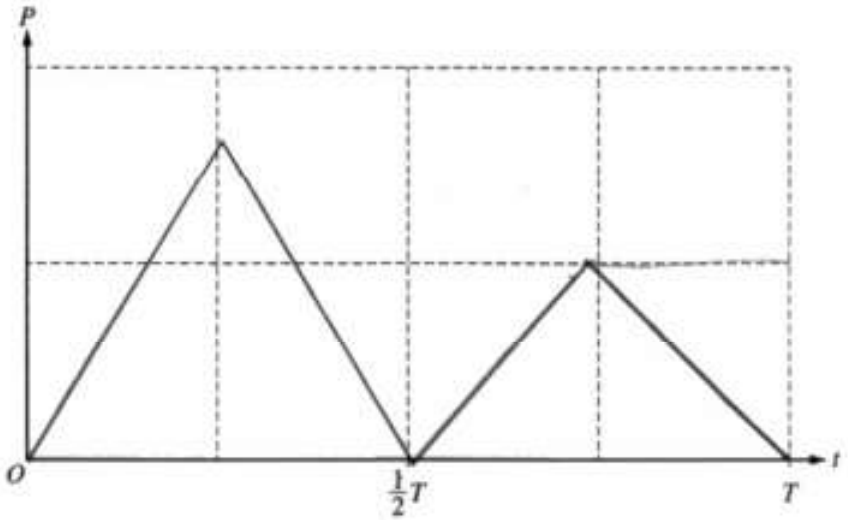

Figure 3

PART D

The sketch drawn in Part C is consistent with the bars drawn in Part A because since $P = I\Delta V$, then P must depend on the induced emf $|\mathcal{E}|$.

Go to Question 3 in Bluebook when you're done with this question.

Question 2

Note: Student samples are quoted verbatim and may contain spelling and grammatical errors.

Overview

NEW for 2025: The question overviews can be found in the *Chief Reader Report on Student Responses* on AP Central.

Sample: 2A
Score: 11

Part A earned two out of three points. The first point (A1) was earned for having a bar drawn at $t = T/4$. The second point (A2) was earned for having a bar drawn at $t = T/4$ that has a height of 3 units. The third point (A3) was not earned because the response does not have "0" written in the column to indicate that the emf is zero at time $t = 0$ and $t = T/2$.

Part B earned all four points. The first point (B1) was earned for providing a multistep derivation that includes a correct equation for Faraday's law. The second point (B2) was earned for correctly taking the derivative of the flux expression. The third point (B3) was earned for correctly substituting the expression for emf into Ohm's law. The fourth point (B4) was earned for providing a correct expression for the absolute value of the maximum induced current.

Part C earned all three points. The first point (C1) was earned for having a graph that is approximately sinusoidal. The second point (C2) was earned for having a graph that shows exactly two complete cycles. The third point (C3) was earned for having a graph that starts at the origin with equal maximum values and equal minimum values.

Part D earned both points. The first point (D1) was earned for correctly indicating that the representations in parts A and C are consistent. The second point (D2) was earned for indicating that power depends upon both current and emf and that current also depends upon emf.

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Question 2 (continued)

Sample: 2B
Score: 7

Part A earned all three points. The first point (A1) was earned for having a bar drawn at $t = T/4$. The second point (A2) was earned for having a bar drawn at $t = T/4$ that has a height of 3 units. The third point (A3) was earned for indicating the emf is "0" in the columns at time $t = 0$ and $t = T/2$.

Part B earned three out of four points. The first point (B1) was earned for providing a multistep derivation that includes a correct equation for Faraday's law. The second point (B2) was earned for correctly taking the derivative of the flux expression. The third point (B3) was earned for substituting emf into Ohm's law to determine induced current. The fourth point (B4) was not earned because the response does not indicate a correct expression for the maximum induced current.

Part C did not earn any of the three points. The first point (C1) was not earned because the response does not show an approximately sinusoidal graph. The second point (C2) was not earned because the response does not show a graph with two complete cycles. The third point (C3) was not earned because the response does not show a graph with equal maximum values and equal minimum values.

Part D earned one out of two points. The first point (D1) was not earned because the response incorrectly indicates that the representations in parts A and C were consistent. The second point (D2) was earned because the response shows that P is proportional to the square of the emf.

Sample: 2C
Score: 4

Part A earned two out of three points. The first point (A1) was earned for having a bar drawn at $t = T/4$. The second point (A2) was not earned because the response has a bar drawn at $t = T/4$ that has a height of 4 units rather than 3. The third point (A3) was earned for indicating the emf is "0" in the columns at time $t = 0$ and $t = T/2$.

Part B did not earn any of the four points. The first point (B1) was not earned because the response is not a multistep derivation, even though it includes a correct equation for Faraday's law. The second point (B2) was not earned because the response does not take the derivative of the flux expression. The third point (B3) was not earned because the response does not use Ohm's law with an expression for emf. The fourth point (B4) was not earned because the response does not provide a correct expression for the absolute value of the maximum induced current.

Part C earned one out of three points. The first point (C1) was not earned because the response has a graph that is not approximately sinusoidal. The second point (C2) was earned because the response has a graph that shows two complete cycles. The third point (C3) was not earned because the response has a graph that does not have equal maximum values.

Part D earned one out of two points. The first point (D1) was earned because the response correctly indicates that the representations in parts A and C are consistent. The second point (D2) was not earned because the response does not indicate that P is proportional to the square of the emf.

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